

MEMO



**BOMBARDIER
AEROSPACE**

Date Dec 3, 2004
To A. Khalili
From S. Black
Subject Flight Test Traces in Support of Pinnacle Accident Investigation
Ref.No. FS/04/601R/065/SB
cc S. Nasry

Introduction

A request was made for flight test data traces pertaining to high altitude engine characteristics. Flight test data from these tests were retrieved and are presented along with the associated flight test plans and observer logs.

Requested Data

A summary of the requested data is presented in Table 1:

Table 1: Requested Data

Attach- -ment	A/C #	Flt#	Comment
1	7001	320	High Altitude natural stalls with notch filled and "FAA" pusher settings
2	7002	205	Transport Canada simulated double engine flameout and re-light
3	7002	246	FAA assessment of revised high altitude stick pusher settings

Attached Documentation

Attached to this note are the data from the requested flights. Included are the pages from the test plan, test card and observer logs for the relevant test

points. Only portions of those documents are supplied in order to keep the attachments to a reasonable size, however the complete documents are available should they be required. Flight test time histories of the relevant parameters, particularly the engine parameters, are provided.

Note Regarding Fuel Flow Parameter

It can be seen that the fuel flow parameter spikes to a high value at the point of fuel shutoff. This is due to the design of the fuel flow sensor which consists of an angled vane on a spring. When fuel is cutoff suddenly, the vane springs back providing spurious readings for several seconds. This is considered normal for that sensor.

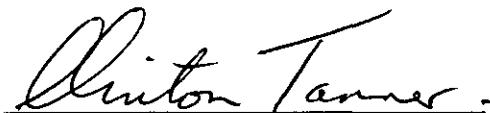
Also, the minimum fuel flow value obtained by this sensor is 200 lbs/hr. Values below that are not recorded.

Additional Flight Test Data

Traces have been requested for Aircraft 7002, Flight 072 from Feb. 15, 1992. There has been some difficulty in recovering this data since the system used to process the original ADAS tapes no longer exists. An effort to recover the data is being made and it will be forwarded as soon as possible.



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C. E. Tanner
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Technical Engineering

Attachment 1: Aircraft 7001, Flight 320

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5.0 TESTS CARRIED OUT & COMMENTS

- 5.1 The primary objective of the Flight was to evaluate if the "Medium Notch Fill" improved the engine operating characteristics at angles of attack equal to the FAA stick pusher settings for buffet deterrent and during high altitude natural stalls. Large drops in P_3 were apparent without the notch fill due to inlet distortion generated by flow separation starting at the leading edge notch.
- 5.2 Tests commenced with a series of wind-up turns to the pusher at FL370. All Test Points were completed through to the pusher with no indication of P_3 anomalies. This showed a significant improvement in engine operating characteristics. The following data was noted :

MACH .75I	MAX α_{NB} . 7.9°	2.2G.	NO P_3 DROPS.
MACH .70I	MAX α_{NB} . 8.6°	1.9G.	NO P_3 DROPS.
MACH .65I	MAX α_{NB} . 9.7°	1.7G.	NO P_3 DROPS.
MACH .60I	MAX α_{NB} . 11.7°	1.6G.	NO P_3 DROPS.

- 5.3 The wind-up turns were then repeated with the pusher disconnected, aiming for a maximum α_{NB} of 1° above the pusher settings. In most cases this was exceeded and large P_3 drops were seen on both engines. The following data was noted :

MACH .75I	MAX α_{NB} . 11.8°	2.26G.	LH 30 PSI/RH 60PSI DROP
MACH .70I	MAX α_{NB} . 11.1°	2.13G.	LH 40 PSI/RH 40PSI DROP
MACH .65I	MAX α_{NB} . 13.5°	1.88G.	LH 50 PSI/RH 50PSI DROP
MACH .60I	MAX α_{NB} . 12.9°	1.57G.	NO P_3 DROPS.
MACH .55I	MAX α_{NB} . 14.4°	1.45G.	LH 35 PSI/RH NO P_3 DROP

All engine anomalies were self-recovering.

- 5.4 The RH stick-shaker was then disconnected by pulling the Cannon Plug and wind-up turn was carried out at M.75 to stick shaker. The object of this exercise was to determine if the Co-Pilot could feel the shaker through the underfloor stick linkage. The Co-pilot was able feel the shaker.
- 5.5 Tests continued with an approach to the natural stall at FL390. During initial natural stall testing the angle of attack for natural stall was determined $14^\circ \alpha_{NB}$. In a nominal 1KT/SEC approach, an angle of attack of $22^\circ \alpha_{NB}$. was reached with no sign of a natural stall, other than a gradual and progressive drop in normal acceleration (NOT a 'G' break). Buffet was low but gradually increasing and there no sign of lateral instability similar to that apparent on the CL601. Massive and irrecoverable P_3 drops were then encountered on both engines and due to rapidly increasing ITT's both engine had to be shutdown.
- 5.6 A sucessful windmill light was achieved on the LH engine approxiamtely 4.5 minutes later followed by a relight of the RH. engine. Tests were terminated at this point for Engineering evaluation.

6.0 PILOTS' COMMENTS.

- 6.1 Issued for information, pending comments.



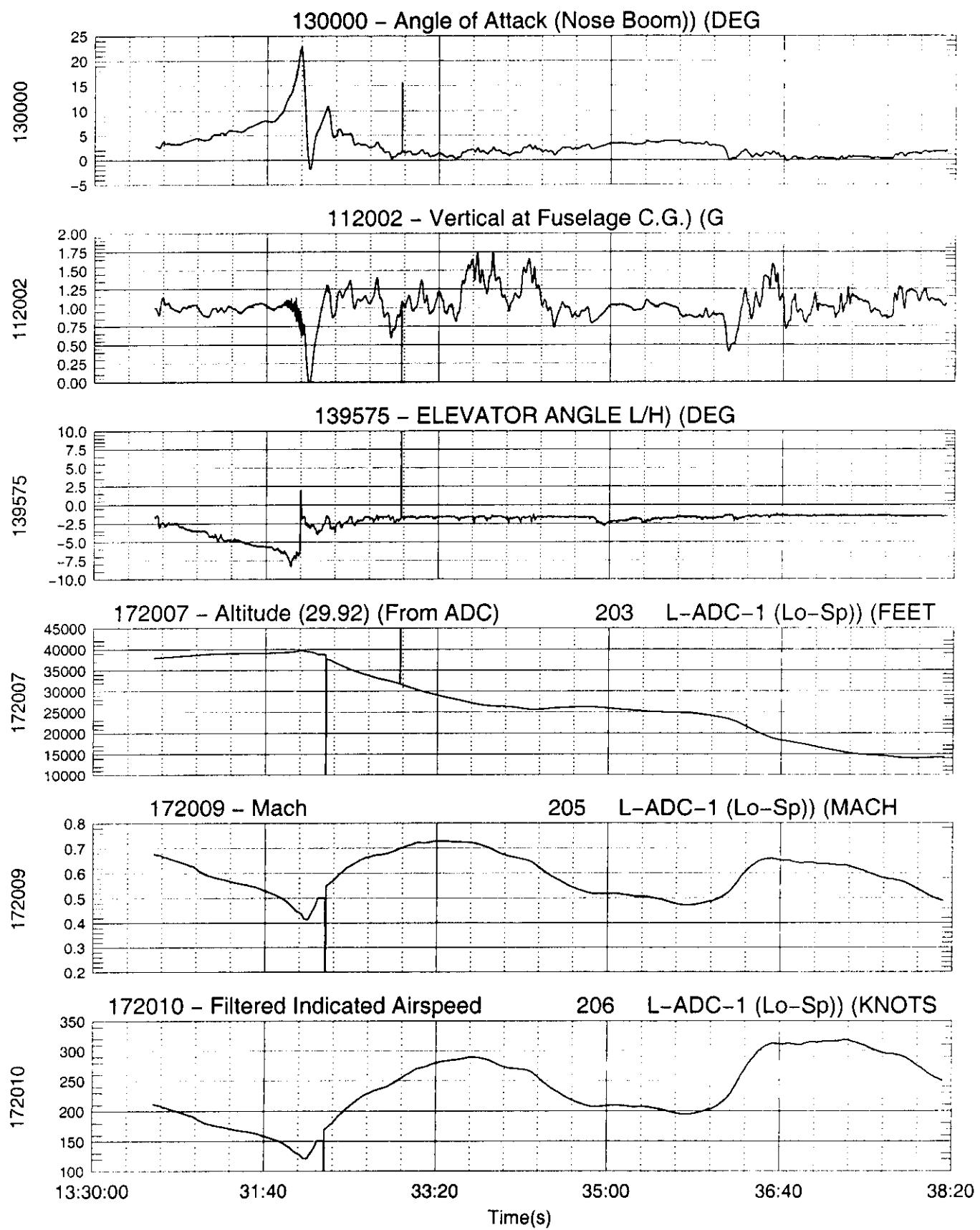
F.D. ADKINS.
CHIEF TEST PILOT.

R.A. BOOTH.
SENIOR FLIGHT TEST ENGINEER.

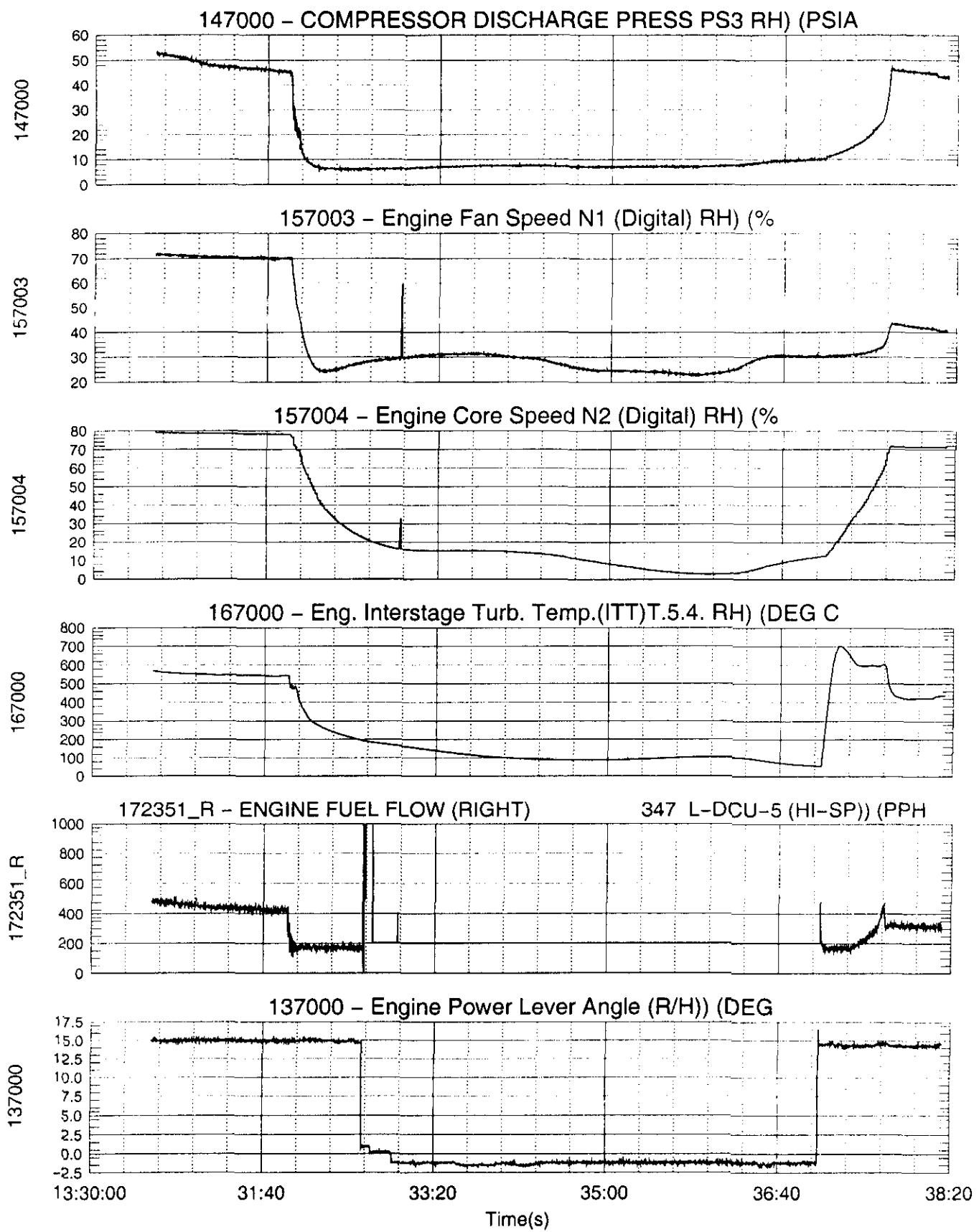
TEST NO	ALT. (FT)	SPEED (KIAS /MN.)	FLAPS	LAND GEAR	L/H	R/H	
8	MAX. PRACT TO FL250	1.4 VS1 TRIM	0°	UP	IDLE	IDLE	CARRY OUT A SERIES OF STRAIGHT 1 KT./SEC. APPROACHES TO THE NATURAL STALL IN A CASCADE FROM THE MAX. PRACTICAL ALTITUDE TO FL250.
9	FL250	260 KIAS TRIM	0°	UP	PFLF	PFLF	<p style="text-align: center;">MACH TRIM - OFF FLAP/STAB I/CON - OFF</p> <p>USING PFLF, TRIM AT 260 KIAS/FL250/FLAP 0°.</p> <p>WITHOUT CHANGING STABILISER TRIM COMPLETE A DESCENT TO 5,000'NOM. AND CARRY OUT A SIMULATED APPROACH AND LANDING IN THE FOLLOWING CONFIGURATIONS :</p> <p>1) FLAP 20°/DWN/V_{REF.}+12KIAS.</p> <p>1) FLAP 45°/DWN/V_{REF.}.</p> <p>ASSESS CONTROL FORCES AND THEN COMPLETE A FULL LANDING IN THE MOST APPROPRIATE FLAP CONFIG'N.</p>

FLIGHT TEST ENGINEERING - OBSERVER'S LOG SHEET						FLT.	DATE	PAGE
TEST POINT	TIME OF DAY	FDA/RJN/RAB	COMMENTS	A/C	FLT.			
		RH	Stuck Shaker Dis Connects				OCT. 1992	5
1 13.22.43		Passing Lost At M.75		7001	320	22ND		
(7) 13.22.21		PUSHER	30 PSI Dead On RH In Heavy					
13.22.50		Rolling Lost						
13.23.06		C.OT	Co-Pilot Can Test RH Shaker					
8 13.30.46		DEC12 FOR NAT STALL AT 12 390						
13.32.30	***	Lost Both Shakers at 220 N8 *						
		Pushout at 22.8 sec						
13.36.55		Tuck-in w/ Engine.						
13.37.06		Tuck-in RH Engine.						
13.37.45		Shaker Start on Both Engines.						
		* APU Five Use.						

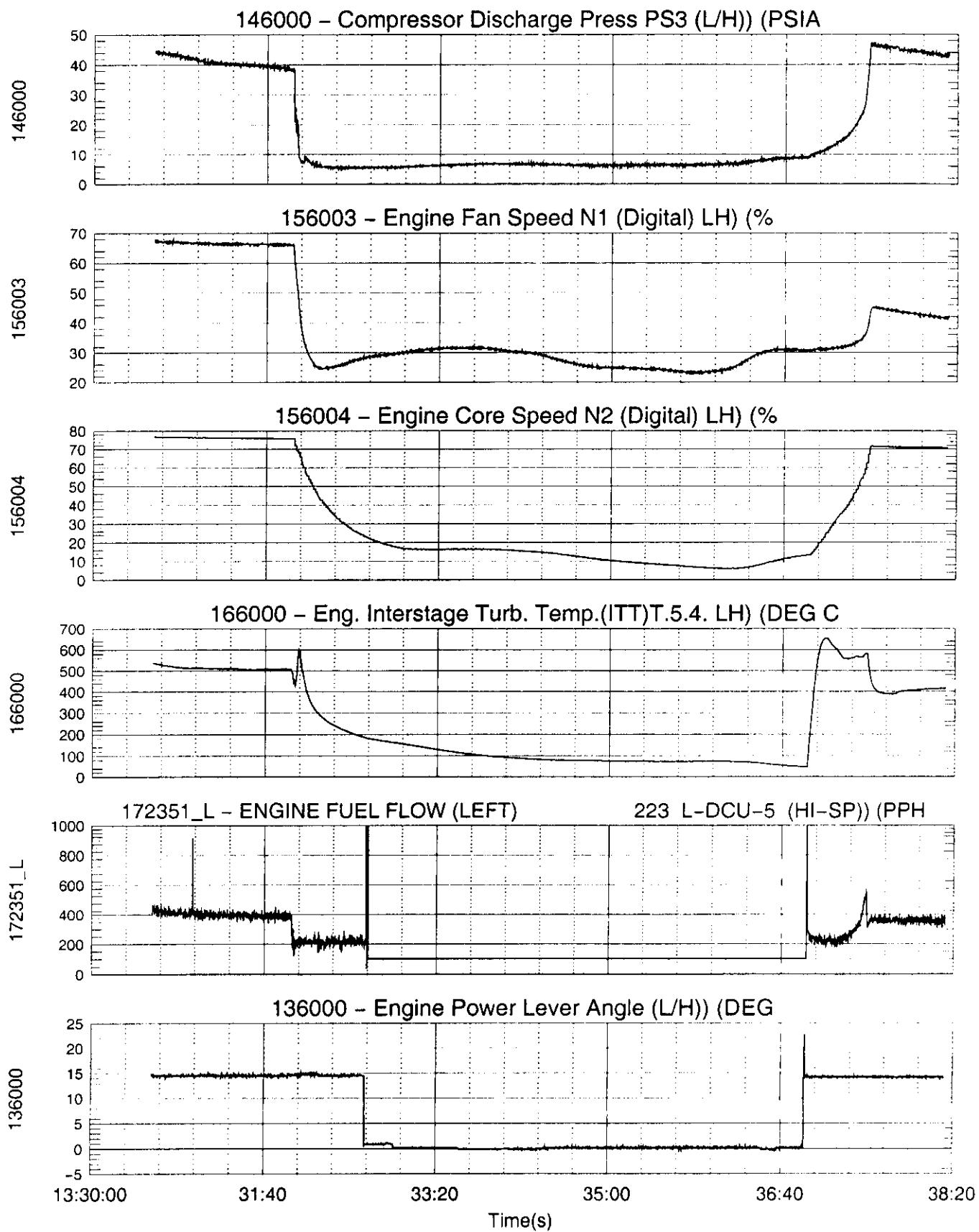
Slow-down to Stall, General Parameters



Slow-down to stall, Right Engine Parameters



Slow-down to Stall, Left Engine Parameters



Attachment 2: Aircraft 7002, Flight 205

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**AIRCRAFT FLIGHT OPERATIONS
ENGINEERING FLIGHT TEST REPORT**

1.0 **AIRCRAFT TYPE** CL601R, Serial No. 7002, C-FNRJ.

1.1 **TEST** Flight No. 205, 28 July 1992, Wichita.

1.2 **CREW**

PILOT: F.D. Adkins.
COPILOT: J. Wormworth.
OBSERVERS: J.W. Brown.
J.C.T. MARTIN

1.3 **FLIGHT TIME**

AIRCRAFT ROLL: 11:06	AIRCRAFT STOP: 14:03	TOTAL: 2 + 57
TAKE-OFF: 11:14	LANDING: 13:54	TOTAL: 2 + 40

2.0 **PROJECT**

Transport Canada evaluation - Control systems failures:
Single hydraulic system failures. (System #1 & system #2).
Lateral axis - Simulation of dual hydraulic system failure.
(System #1 & system #3).
Longitudinal axis - Simulation of dual hydraulic failure. (System
#1 & system #3).
Simulated double engine failures.

2.1 **FLIGHT PLAN**

2FP/205

3.0 **CONFIGURATION**

Ground spoiler downlocks installed.
Engine driven hydraulic pump shut-off valves active.

3.1 **WEIGHT AND BALANCE**

LOAD SHEET NO: CL601R-7002-58
RAMP WEIGHT: 47,481 lbs.
RAMP FUEL: 11,370 lbs.
C OF G: 20.2% M.A.C.

3.2 **AIRCRAFT STATUS**

Aircraft released for flight within the limits of the relevant
R.S.I.'s and prebriefed engineering instructions.

4.0 **INSTRUMENTATION**

I.T.A.S. as required by engineering.

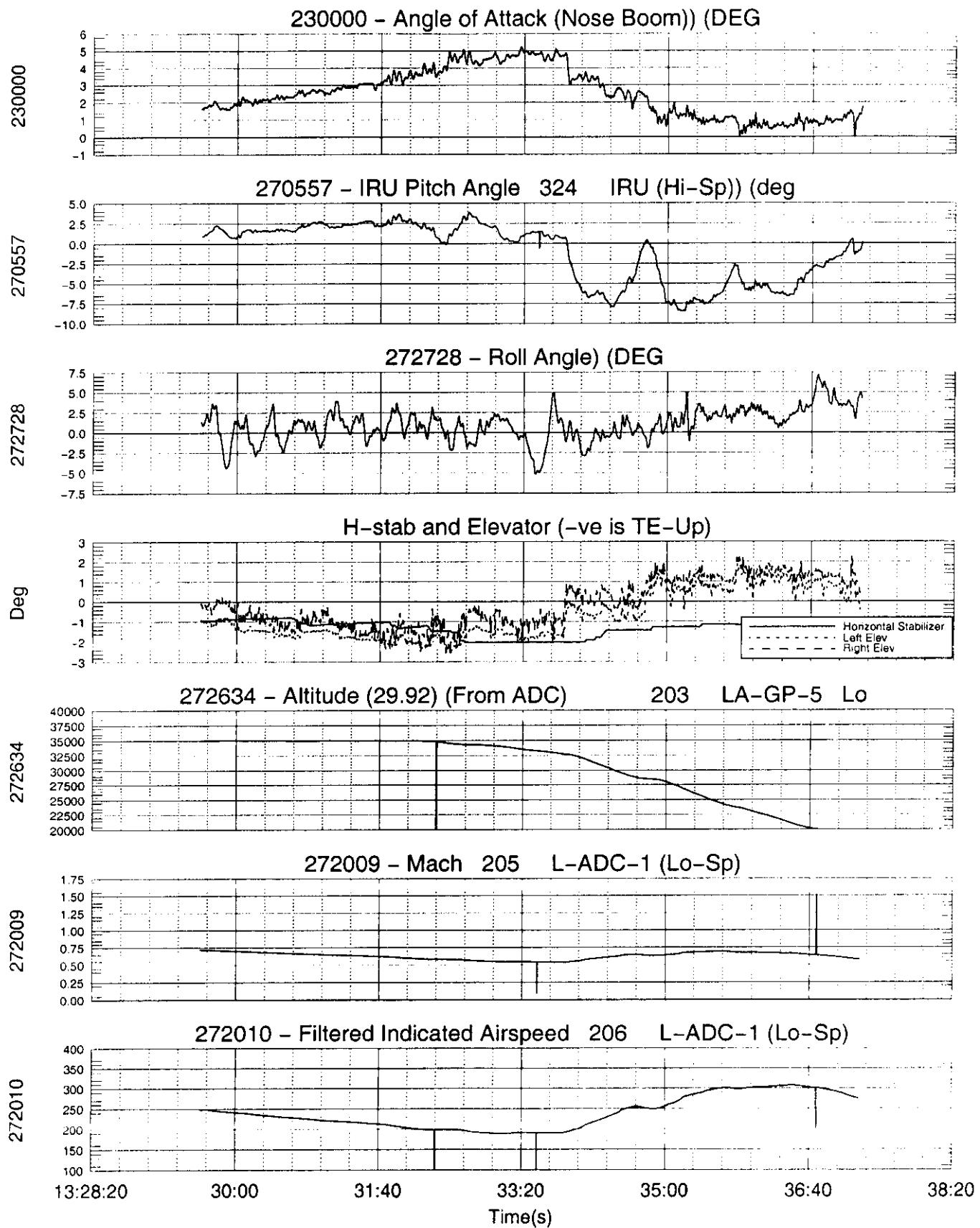
TEST NO	ALT. (FT)	SPEED (KIAS / MN.)	FLAPS	LAND GEAR	POWER L/H	R/H	<u>SIMULATED DOUBLE ENGINE FAILURE</u>																																	
							<p>A.P.U. - ON GEN.3 - OFF</p> <p>AT 0.74 M.I. / 35,000 FT REDUCE PWR. ON THE R/H ENGINE TO IDLE.</p> <p>AFTER A 2 MIN. DELAY BRING PWR. ON THE L/H ENG. TO IDLE & SELECT GEN.1 - OFF.</p> <p>COMMENCE A DRIFTDOWN.</p> <p>SHUTDOWN THE R/H ENGINE & CONFIRM AN A.D.G. AUTO DEPLOY.</p> <p>POST SHUTDOWN</p> <table border="1"> <tr><td>STAB. TRIM CH. #2</td><td>- ENGAGE</td></tr> <tr><td>YAW DAMP. #1 & 2</td><td>- ENGAGE</td></tr> <tr><td>GEN.2</td><td>- OFF</td></tr> <tr><td>HYD. PUMP 2B</td><td>- ON</td></tr> <tr><td>FUEL PUMPS</td><td>- ON</td></tr> <tr><td>ALL A/ICE</td><td>- OFF</td></tr> <tr><td>R/H 10TH STAGE</td><td>- CLOSED</td></tr> <tr><td>GEN.3</td><td>- ON</td></tr> </table> <p>AT 25,000 FT (NOM.), PUSHOVER SUCH AS TO ACHIEVE 13% N₂ AT :- 300 KIAS / 21,000 FT</p> <p>PRE-START CONFIRM</p> <table border="1"> <tr><td>FUEL PUMPS</td><td>- ON</td></tr> <tr><td>CONT. IGN.</td><td>- ON</td></tr> </table> <p>CARRY OUT A WINDMILL AIRSTART</p> <p>POST START</p> <table border="1"> <tr><td>R/H 10TH STAGE</td><td>- OPEN</td></tr> <tr><td>R/H ACU</td><td>- ON</td></tr> <tr><td>GEN.1</td><td>- ON</td></tr> <tr><td>GEN.2</td><td>- ON</td></tr> <tr><td>HYD. PUMP 2B</td><td>- AUTO</td></tr> <tr><td>CONT. IGN.</td><td>- OFF</td></tr> </table>		STAB. TRIM CH. #2	- ENGAGE	YAW DAMP. #1 & 2	- ENGAGE	GEN.2	- OFF	HYD. PUMP 2B	- ON	FUEL PUMPS	- ON	ALL A/ICE	- OFF	R/H 10 TH STAGE	- CLOSED	GEN.3	- ON	FUEL PUMPS	- ON	CONT. IGN.	- ON	R/H 10 TH STAGE	- OPEN	R/H ACU	- ON	GEN.1	- ON	GEN.2	- ON	HYD. PUMP 2B	- AUTO	CONT. IGN.	- OFF
STAB. TRIM CH. #2	- ENGAGE																																							
YAW DAMP. #1 & 2	- ENGAGE																																							
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HYD. PUMP 2B	- ON																																							
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R/H 10 TH STAGE	- OPEN																																							
R/H ACU	- ON																																							
GEN.1	- ON																																							
GEN.2	- ON																																							
HYD. PUMP 2B	- AUTO																																							
CONT. IGN.	- OFF																																							
19	21000	300 KIAS	0°	UP	A.R.	OFF	<p>NOTE: RECORD AIRSPEED & TIME THAT ADG IS DEPLOYED ABOVE 250 KIAS.</p>																																	

COMMENTS (Test #19)

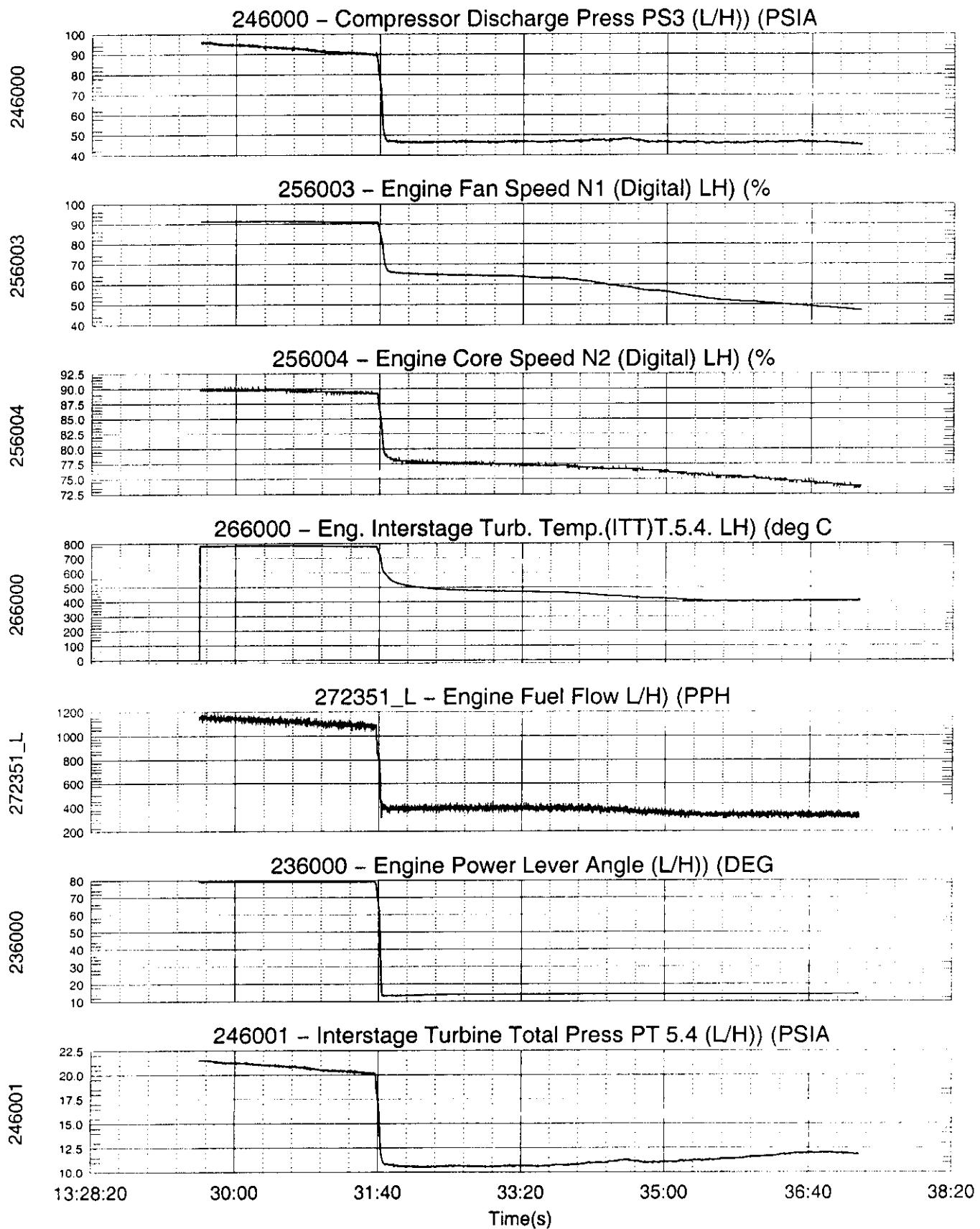
Test was carried out as written, ADG auto deploy occurred normally & a windmill relight was carried out at 21,000 ft, 300 KIAS with fuel in at 13% N₂. The relight was satisfactory with a max. ITT of 808°.

FLIGHT TEST ENGINEERING - OBSERVER'S LOG SHEET			A/C	FLT.	DATE	PAGE
TEST POINT	TIME OF DAY	COMMENTS	7002 C-FNRJ	205	28 JULY '92	8 OF
18	124450	137 KIAS / Sf 45° DOWN PELF MANOEUVRING				
	12 4510	30° LWD BANK TURN ~ 40° RWD BANK TURN.				
	124634	137 KIAS / Sf 45° DOWN PWR 3° GS				
	124700	FLARE				
	124719	SIM. GO-AROUND				
		No/CA LIMIT CHECK 190 KIAS 35000' SAT -44°C				
	131130	R/H ACU OFF.				
	131221	L/HENG TO 94.5% N, MAX.CONT 91.2% N ₂ 819° ITT				
19	132042	0.74M.I., 35000' SAT -44°C				
	132938	R/HENG TO IDLE				
	133141	L/HENG. TO IDLE ~ GEN. I OFF				
	133250	COMMENCE DRIFTDOWN 190 KIAS				
	133204	R/HENG SHUTDOWN ~ ADG AUTO DEPLOY				
	133250	COMMENCE PUSHOVER				
	133430	250 KIAS				
	133629	FUEL IN 300KIAS / 21,000' 18% N ₂ 808° ITT MAX				
	133709	E.O.T.				

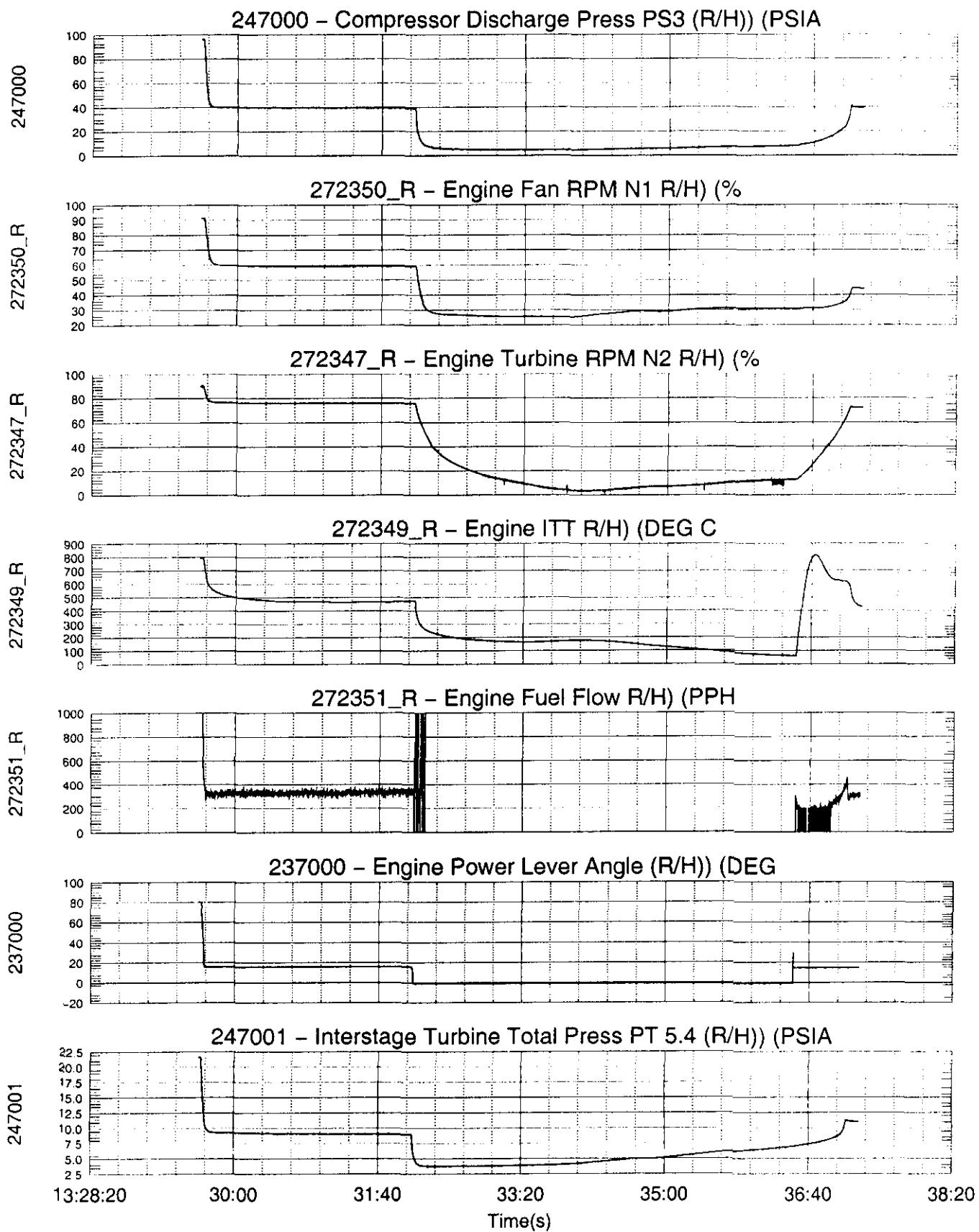
General Parameters



Left Engine Parameters



Right Engine Parameters



Attachment 3: Aircraft 7002, Flight 246

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RAY 1:

AIRCRAFT FLIGHT OPERATIONS
ENGINEERING FLIGHT TEST REPORT

1.0 **AIRCRAFT TYPE** CL601R, SERIAL NO. 7002, C-FNRJ.

1.1 **TEST** FLIGHT NO. 246, 20 OCTOBER 1992, WICHITA.

1.2 **CREW**

PILOT: L.B. (FAA)
COPILOT: F.D. ADKINS
OBSERVER: R.A. BOOTH

1.3 **FLIGHT TIME**

AIRCRAFT ROLL: 13:11	AIRCRAFT STOP: 14:48	TOTAL: 1 + 37
TAKE-OFF: 13:20	LANDING: 14:42	TOTAL: 1 + 22

2.0 **PROJECT**

FAA ASSESSMENT OF DETERRENT BUFFET LEVEL.

2.1 **FLIGHT PLAN**

2FP/246

3.0 **CONFIGURATION**

PRODUCTION STALL PROTECTION SYSTEM SETTINGS. SHAKER ADVANCED AHEAD OF BUFFET BOUNDARY ONSET LEVEL.

3.2 **WEIGHT AND BALANCE**

LOAD SHEET NO: CL601R-7002-62
RAMP WEIGHT: 47,144 LBS.
RAMP FUEL: 9,620 LBS.
C OF G: 35.0% MAC.

3.2 **AIRCRAFT STATUS**

AIRCRAFT RELEASED FOR FLIGHT WITHIN THE LIMITS OF THE RELEVANT RSI'S AND PREBRIEFED ENGINEERING INSTRUCTIONS.

4.0 **INSTRUMENTATION**

I.T.A.S. AS REQUIRED BY ENGINEERING.
TELEMETRY.

RAY 1:

5.0 TESTS CARRIED OUT & COMMENTS

- 5.1 The objective of this Flight was an FAA assessment of the revised high altitude stick pusher settings for engine inlet distortion protection above Mach .55 during inadvertant buffet penetration. The Flight commenced with a series of straight, power-off, 1KT/SEC. approaches to the pusher in order to familiarise the FAA with the pusher recovery characteristics. This was followed by an evaluation of stick force/G at 250 KIAS/15,000'. The maximum G limit of 2.5G was achieved with a slight hint of buffet. The FAA Pilot considered this sufficient familiarisation and the additional stability Test Points planned were deleted in favour of the primary Flight objectives.
- 5.2 The flight continued with a Company demonstration of deterrent buffet level at M.70/FL370. The point was completed satisfactorily up to the maximum α_{NB} briefed of 8.5°. The FAA then repeated this Test Point, reaching a maximum α_{NB} , of 12°, accompanied by significant but self-recovering P₃. drops of 40/50 PSI on the LH and RH engine respectively. Mach Number had dropped off to .68M during the point and it was decided to repeat the point. In the wind-up turn to the left, the Test Point was completed satisfactorily with a maximum α_{NB} , of 8° and 1.5G. The roll to the right was continued through the pusher (8.5°) to a maximum α_{NB} of 13° and 1.9G. Both LH and RH engines suffered massive P₃ drops and rolled back below IDLE. Both engines had to be shutdown.
- 5.3 A sucessful Windmill relight was carried out on the LH engine, 3 minutes after shutdown at FL210/330KIAS, followed by a sucessful ATS on the RH engine a further 90 SECS. later. Tests were terminated at this point.

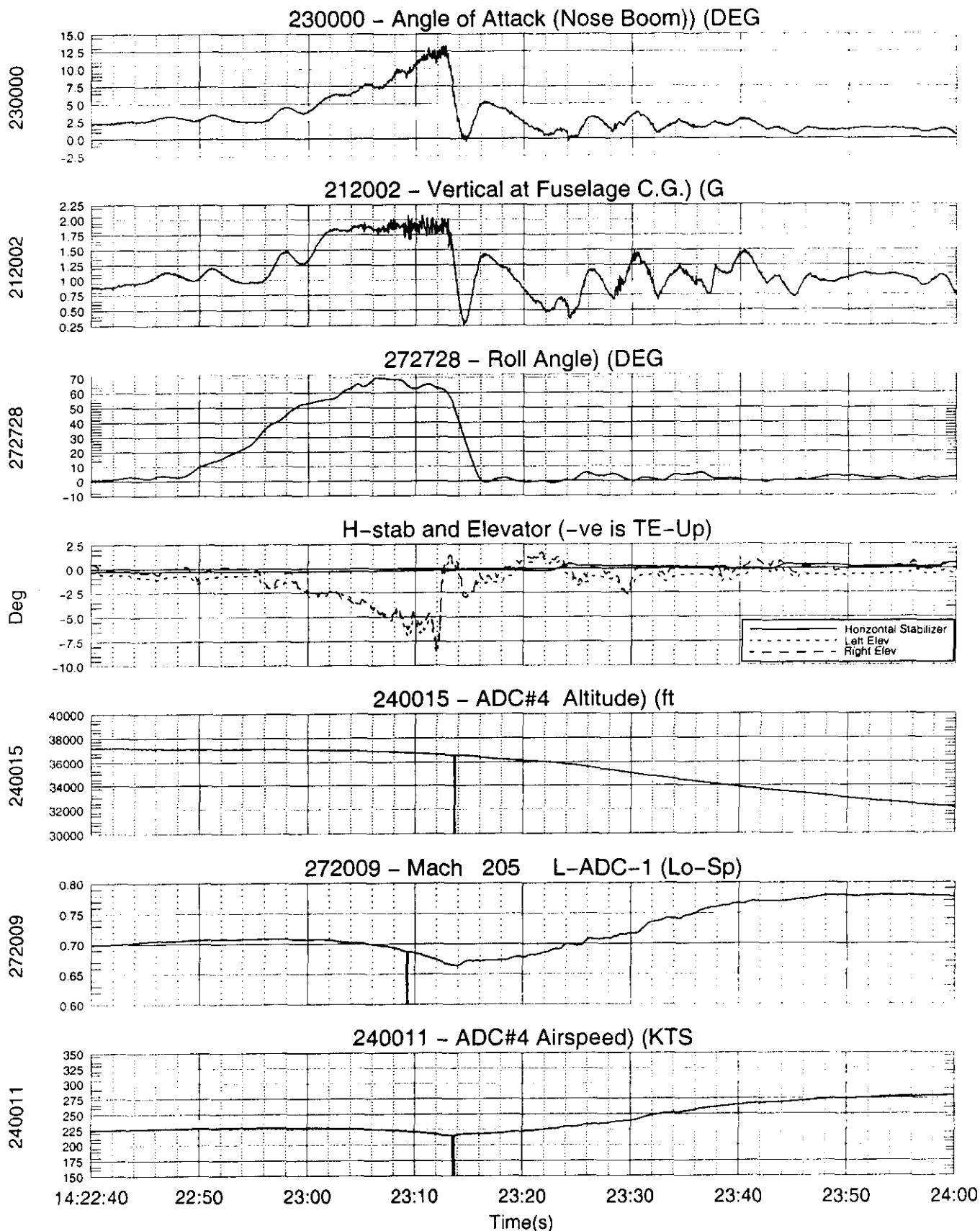
6.0 PILOTS' COMMENTS.

- 6.1 Not applicable, see FAA De-Brief Note.

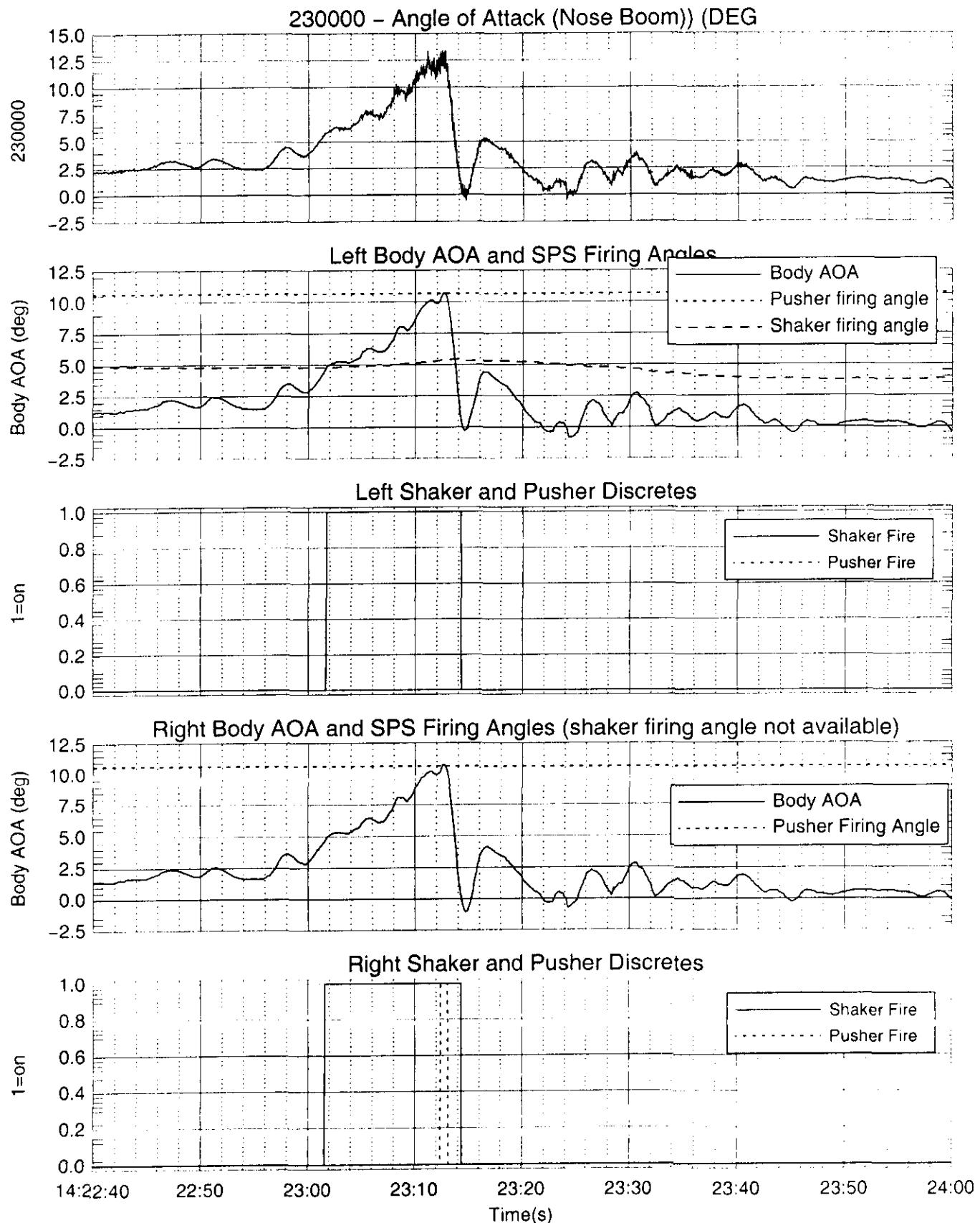
TEST NO	ALT. (FT)	SPEED (KIAS / MN.)	FLAPS	LAND GEAR	POWER L/H	R/H	
8	15000 NOM	250 KIAS TRIM	0°	UP	PFLF	PFLF	DYNAMIC LONGITUDINAL STABILITY ASSESS DYNAMIC LONGITUDINAL STABILITY IN THE NOTED CONFIGURATION.
9	CLIMB	250 KIAS	0°	UP	MAX CLB	MAX CLB	STATIC LONGITUDINAL STABILITY CARRY OUT A STATIC LONG. STAB LOOP BETWEEN V_{BC} (250KIAS) $\pm 15\%$
10	MAX PRACT	0.80 M.I. TRIM	0°	UP	AS REQ'D	AS REQ'D	BUFFET BOUNDARY PENETRATION. CARRY OUT CONSTANT MACH. NUMBER WIND-UP TURNS UNTIL REACHING ONE OF THE FOLLOWING CRITERIA:- DETERRENT BUFFET. STICK PUSHER ACTIVATION. 2.5 'G' MAN. LOAD FACTOR.
11	MAX PRACT	0.75 M.I. TRIM	0°	UP	AS REQ'D	AS REQ'D	
12	MAX PRACT	0.70 M.I. TRIM	0°	UP	AS REQ'D	AS REQ'D	
13	MAX PRACT	0.65 M.I. TRIM	0°	UP	AS REQ'D	AS REQ'D	
14	MAX PRACT	0.60 M.I. TRIM	0°	UP	AS REQ'D	AS REQ'D	

FLIGHT TEST ENGINEERING - OBSERVER'S LOG SHEET			A/C	FLT.	DATE	PAGE
TEST POINT	TIME OF DAY	LB (FAA)/FDA/RAB COMMENTS	47,144 LB.	7002	246	20TH OCT. 1992
12.	1413.40	FAA TRIM H-70				4. OF
	1415.00	ROLLING LOFT.				
	1415.21	G.O.T BIG P3 DROP ON BOTH. 40/50 12.0 MAX 12.50 MAX .70 & .68 1.96. FAA.				PSI.
	1419.18	ROLLING LOFT				
	1419.43	G.O.T. 80° MAX. (80 _{max} 1.5G)				
	1422.50	ROLLING RIGHT				
*	1423.15	PUSHER BOTH ENGINES FLAMED OUT *				
		12.500 NB.				
	1426.10	W/MILL RE-LITE LH ENGINE.				
	1427.00	STABLE START LH ENGINE.				
	1427.37	X-BLEED START ON RH ENGINE.				
	1428.10	STABLE START.				

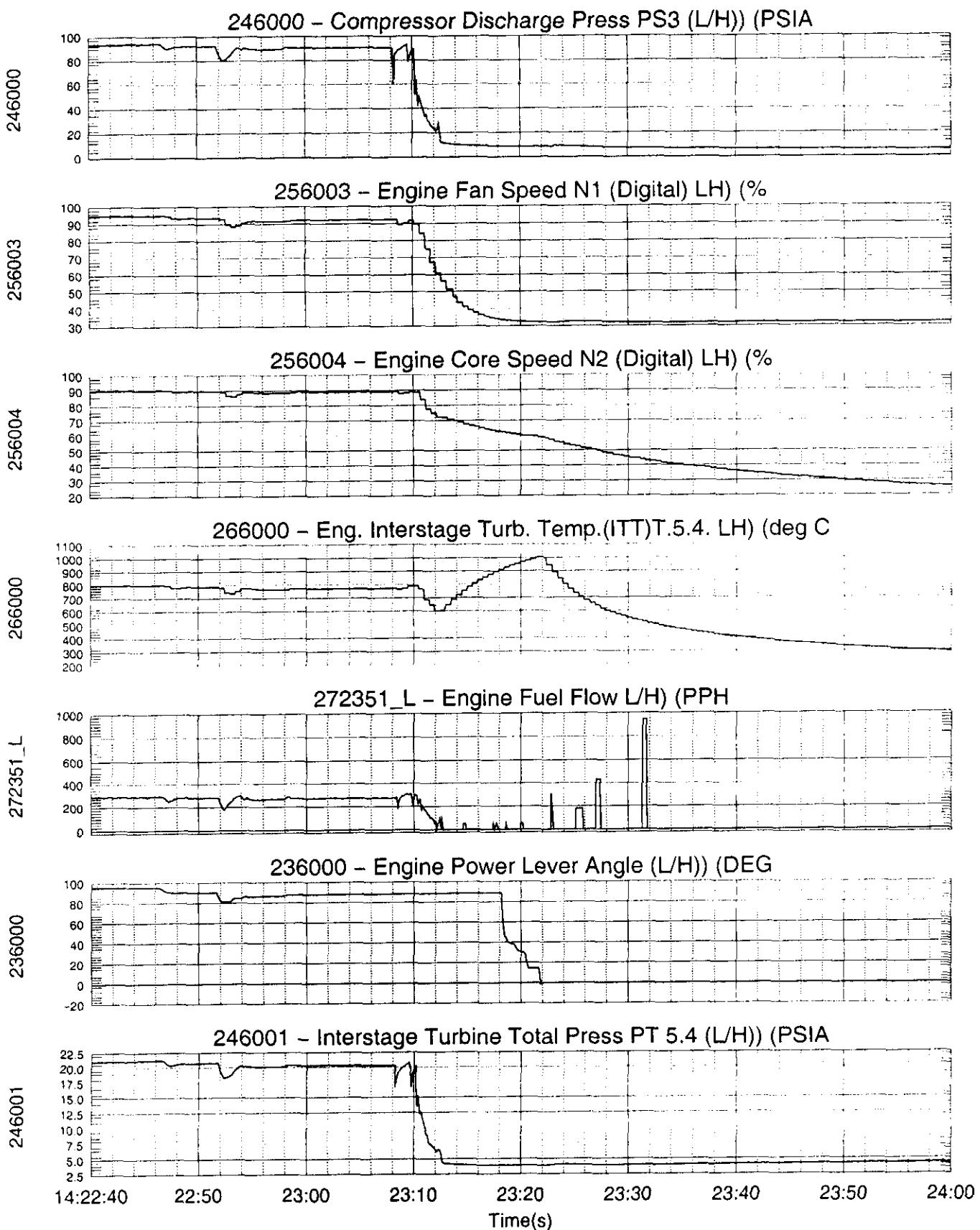
Wind Up Turn, General Parameters



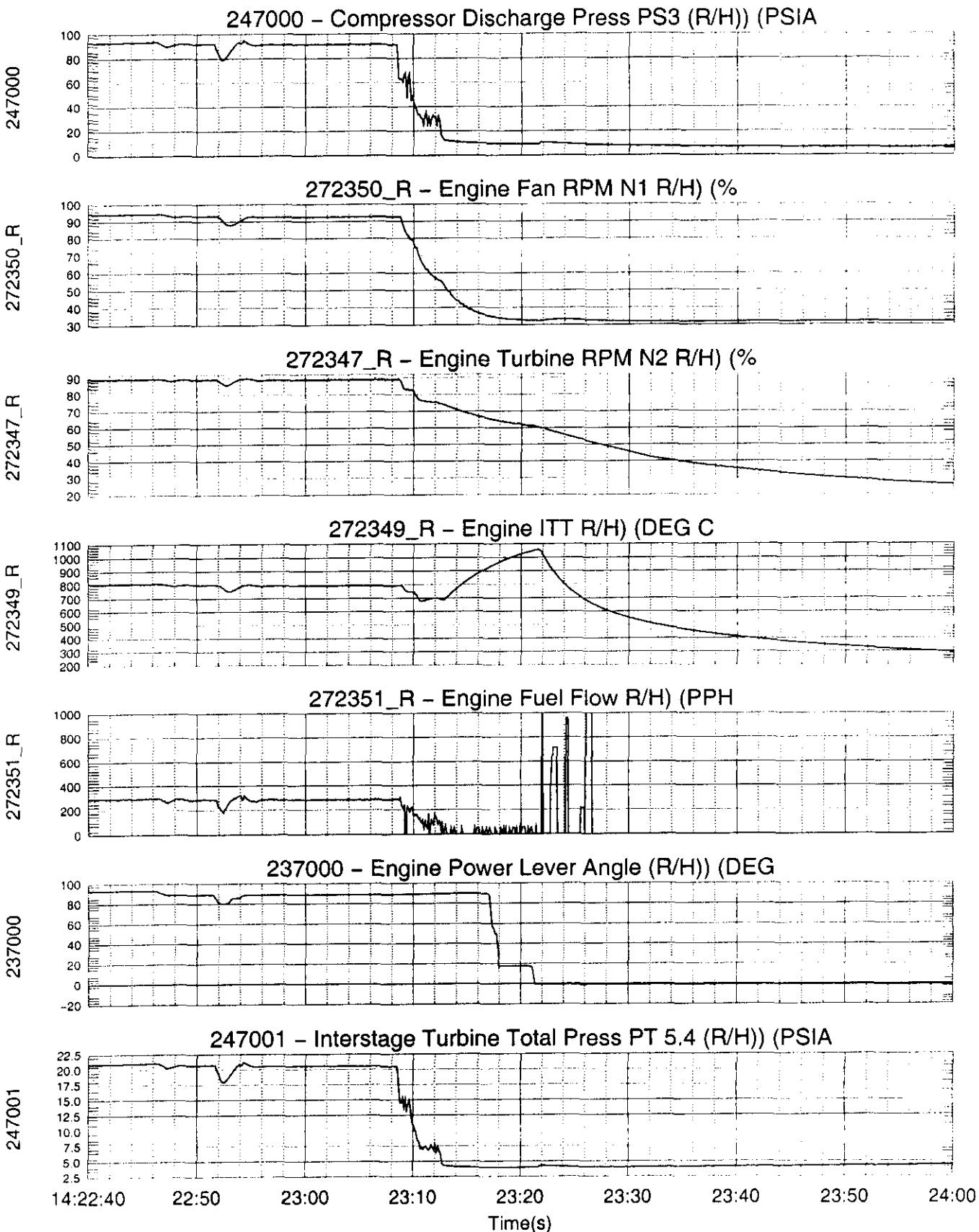
Wind-Up Turn, AOA and SPS parameters



Wind-up Turn, Left Engine Parameters

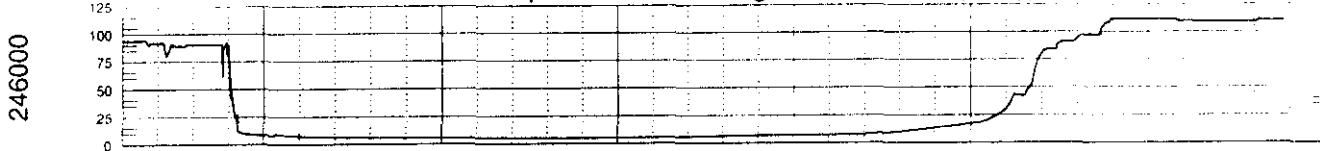


Wind-Up Turn, Right Engine Parameters

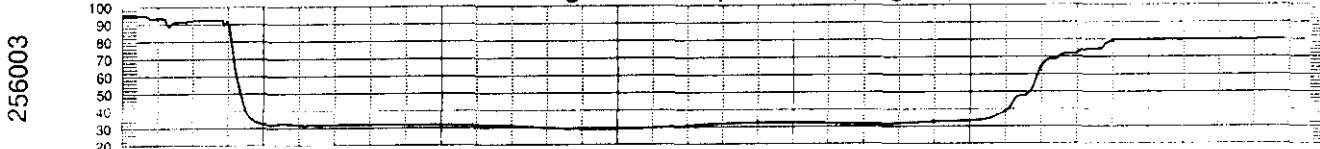


Flameout and Relight, Left Engine Parameters

246000 – Compressor Discharge Press PS3 (L/H) (PSIA)



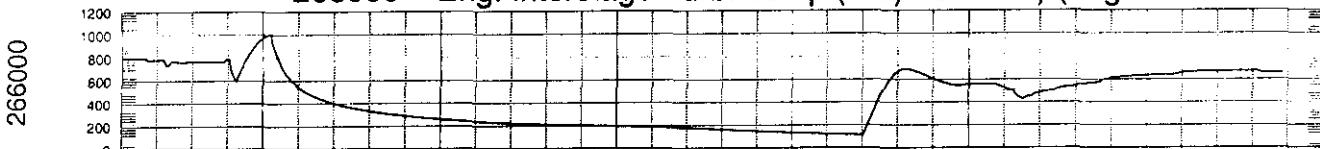
256003 – Engine Fan Speed N1 (Digital) LH (%)



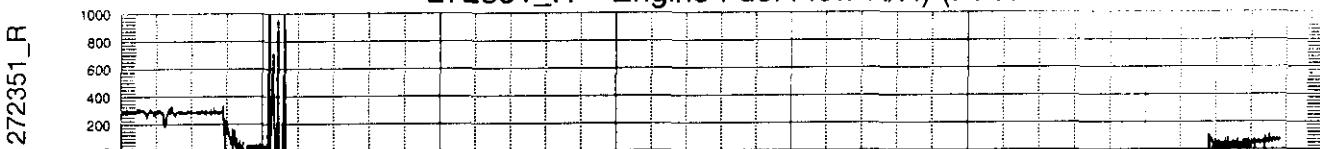
256004 – Engine Core Speed N2 (Digital) LH (%)



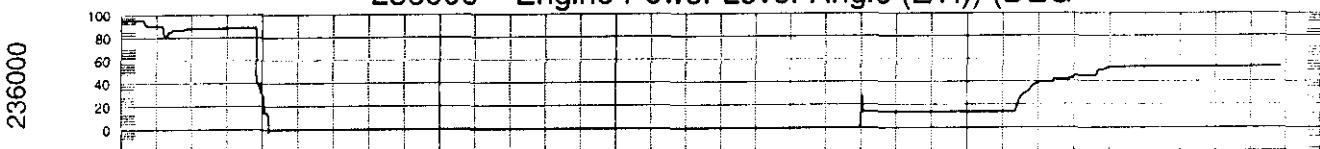
266000 – Eng. Interstage Turb. Temp.(ITT)T.5.4. LH) (deg C)



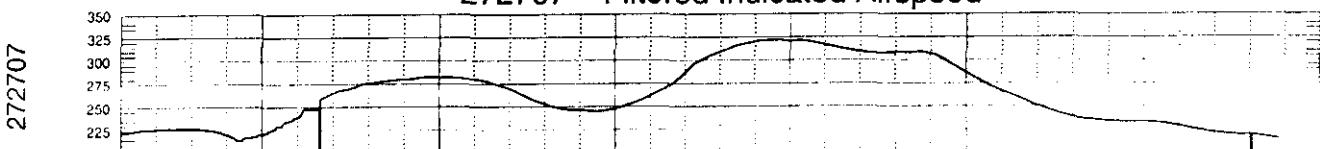
272351_R – Engine Fuel Flow R/H) (PPH)



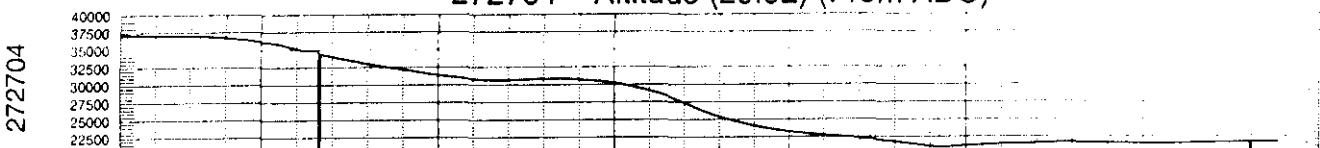
236000 – Engine Power Lever Angle (L/H)) (DEG



272707 – Filtered Indicated Airspeed



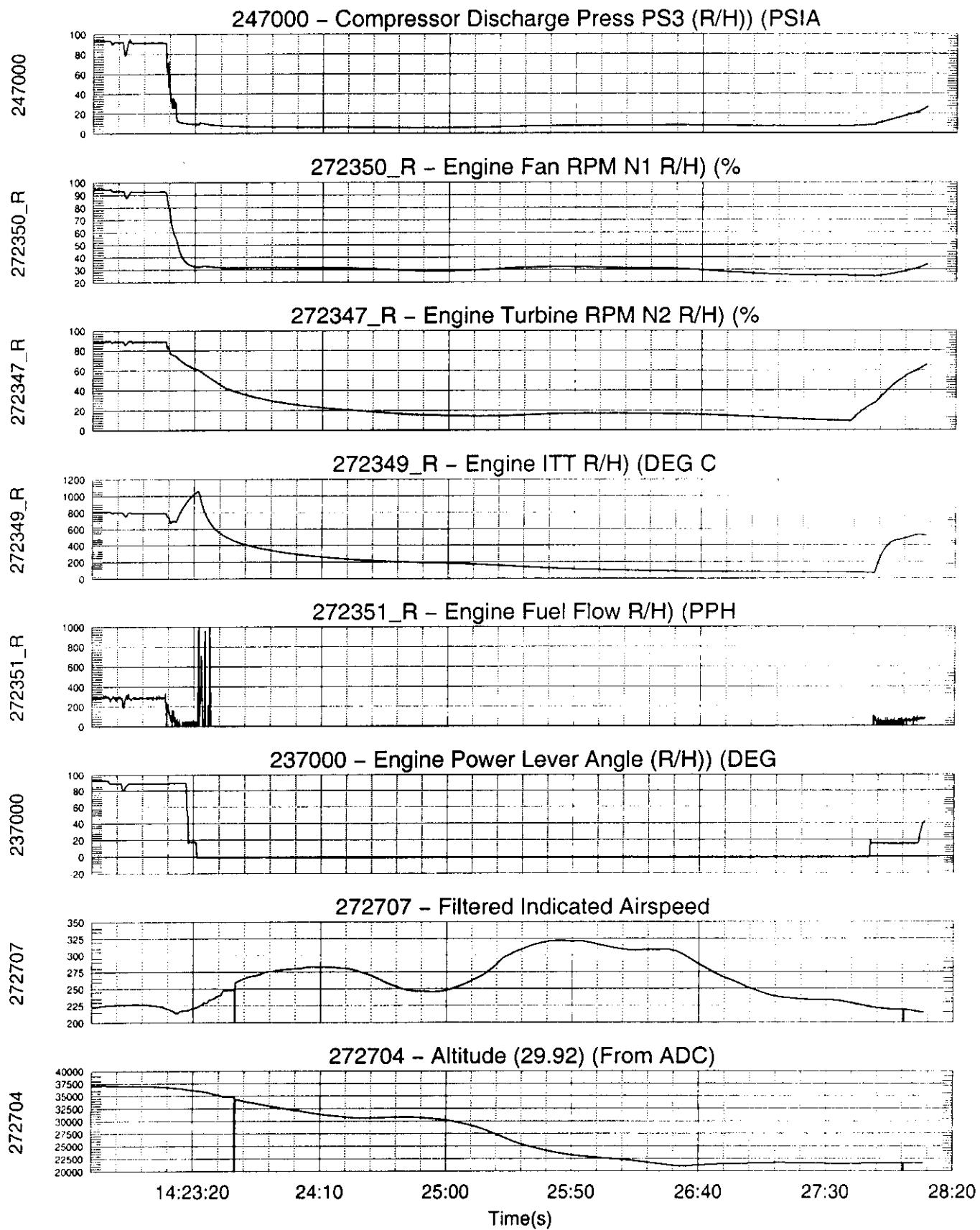
272704 – Altitude (29.92) (From ADC)



Time(s)

14:23:20 24:10 25:00 25:50 26:40 27:30 28:20

Flameout and Relight, Right Engine Parameters



MEMO

Item 24

Enq. Request 631



**BOMBARDIER
AEROSPACE**

Date Dec 20, 2004
To A. Khalili
From S. Black
Subject Additional Flight Test Traces in Support of Pinnacle Accident Investigation
Ref.No. FS/04/601R/076/SB
cc S. Nasry, G. Browning

References

- 1) FS/04/601R/065/SB, "*Flight Test Traces in Support of Pinnacle Accident Investigation*", Dec 03/04

Introduction

In Reference 1, flight test time histories were provided for specific test points pertaining to engine flame-outs and re-lights. One set of traces was not included due to problems with extracting archived data, namely Flight 072 from Aircraft 7002. These traces are provided in this memo.

Background

On flight 072 of Aircraft 7002, a windmill re-light was attempted starting from 28900 ft at 190 KIAS. At 18000 ft, 360 kts, N2 remained at 0. A second push-over was performed from 15,500 ft down to 12000 ft where a successful re-light was performed. Extraction of this flight test data proved difficult due to the fact that the stored processed data was found to be corrupted and the raw data was from a data acquisition system (DAS) that was decommissioned several years ago. Reprocessing this data required a calibration database that is no longer available. Those portions of the flight and those parameters that could be recovered are presented in this note.

BOMBARDIER PROPRIETARY INFORMATION

Data Quality

In can be seen from the time history data that there are numerous data spikes. Additional parameters, such as oil temperature and pressure, could not be recovered due to the issues described above. Note that between 15:45:31 and 15:48:41 the DAS was shut down so all data in this interval is invalid.

Each data trace is made up of 3 separate time slices which are plotted in different colors and line-styles, however they are all correctly placed with respect to the time axis.

Any questions about the data calibrations and engine behaviour should be addressed to the Power Plant group (G. Browning).



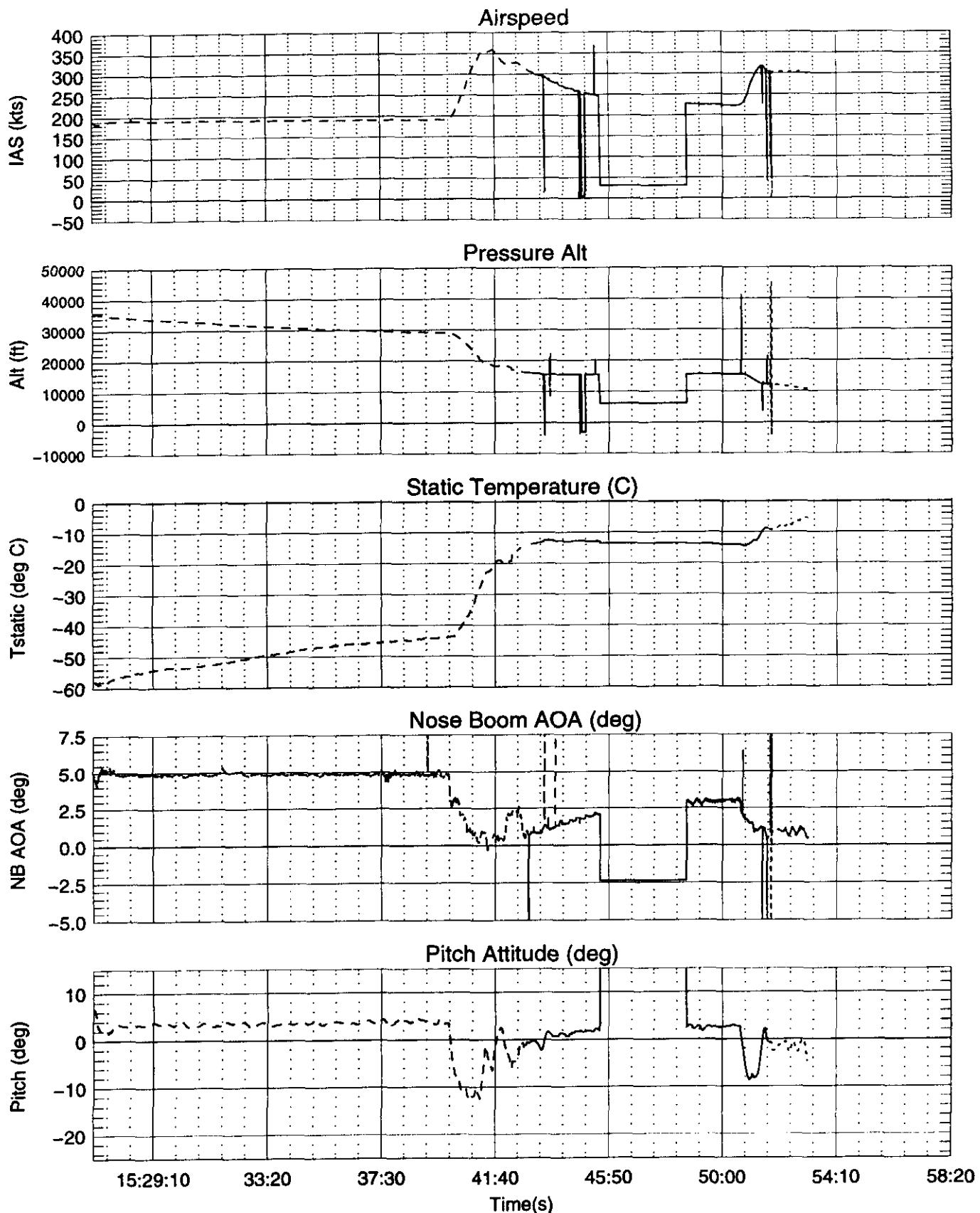
S. Black
Flight Sciences



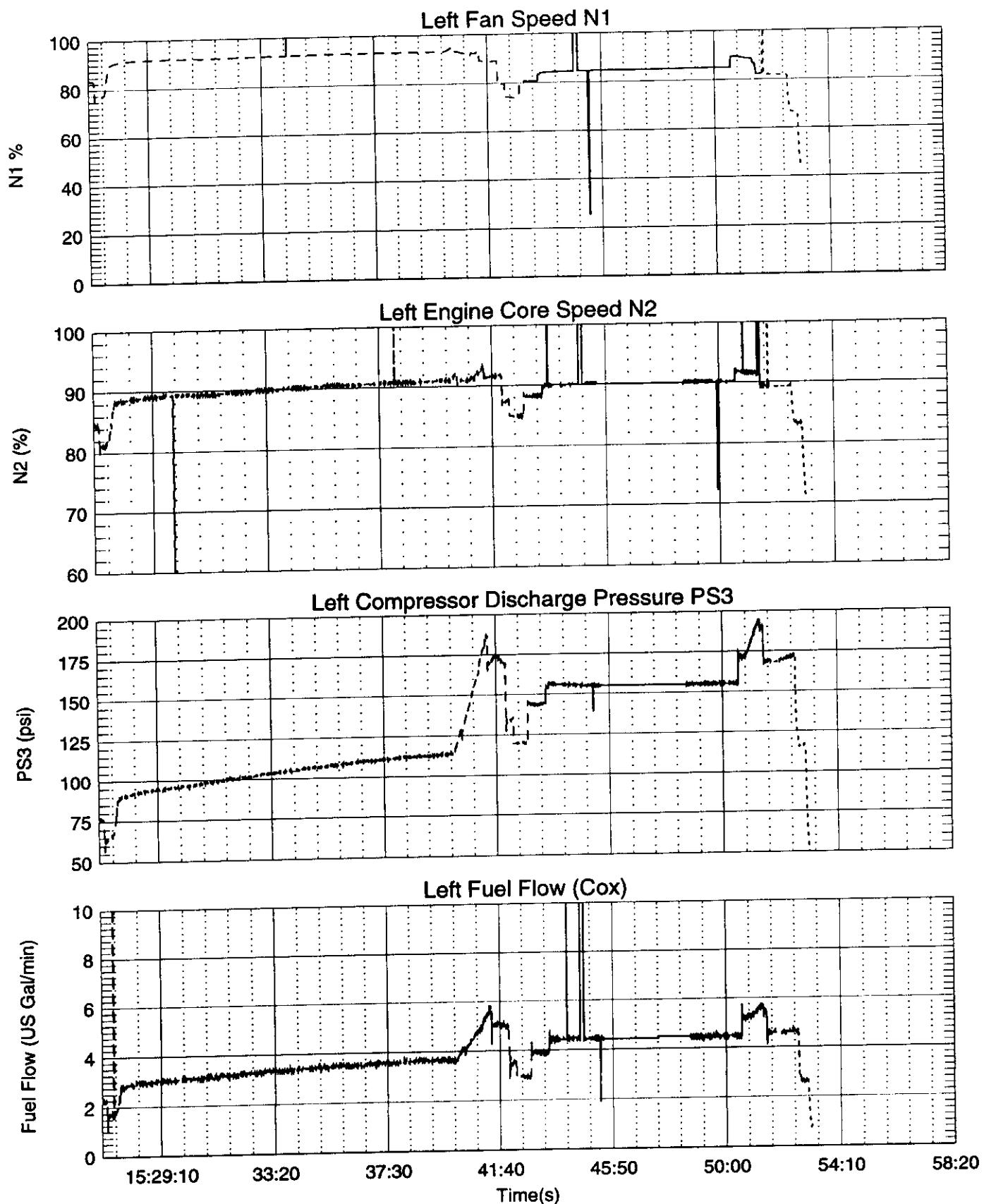
C. E. Tanner
Senior Advisor, Technical Engineering

BOMBARDIER PROPRIETARY INFORMATION

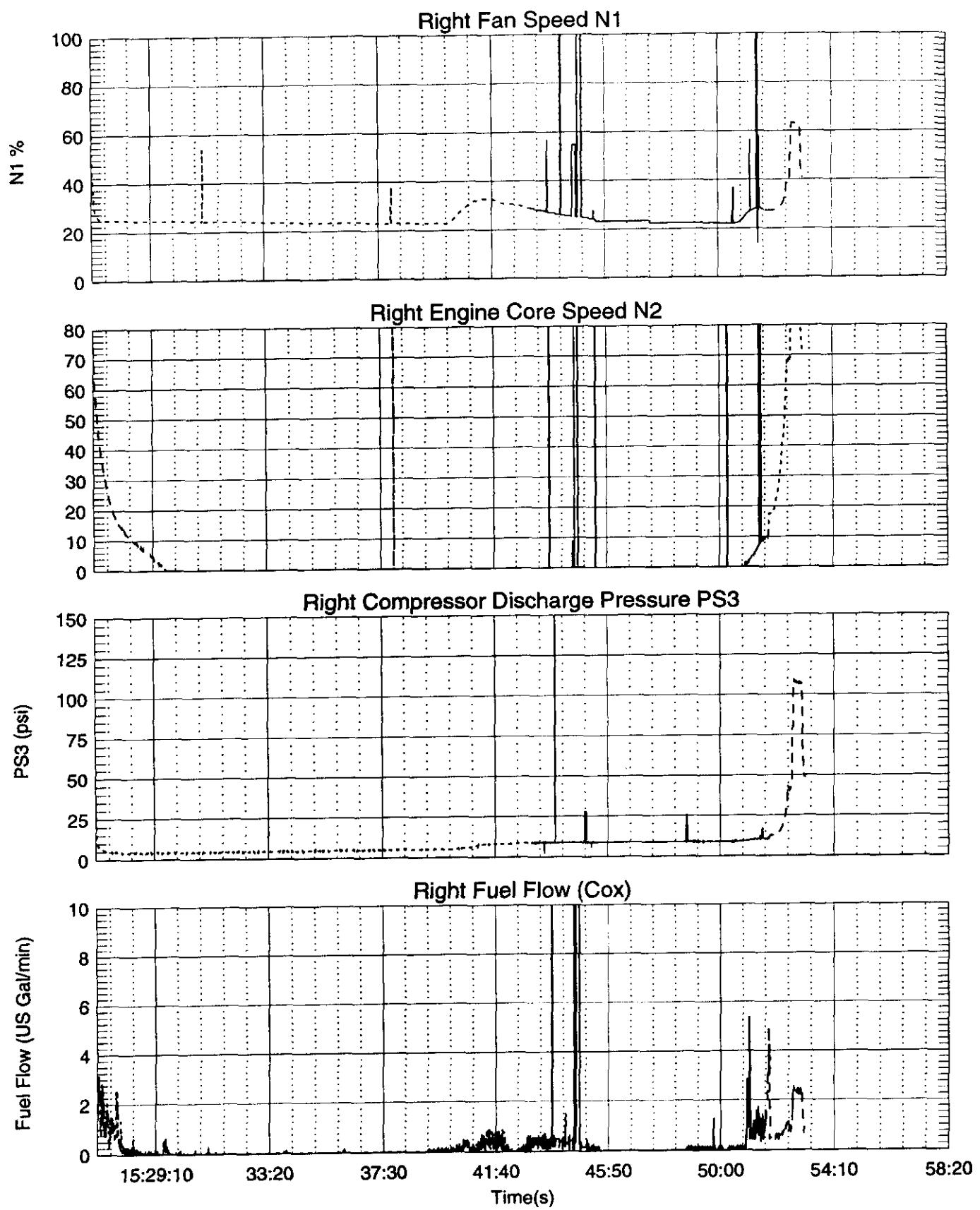
AC 7002, Flight 072, Test Point 14A



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